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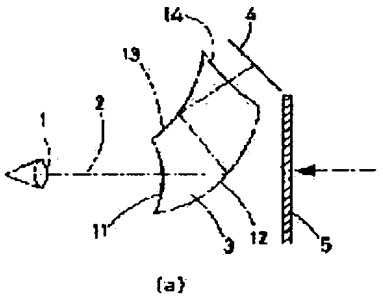
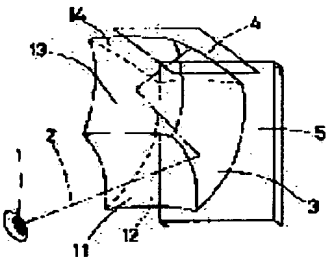
(54) PICTURE DISPLAY DEVICE

(57)Abstract:
PROBLEM TO BE SOLVED: To provide a picture display device capable of observing a picture display element in wide field angle and high resolution states through the device is compact and light and observing an external image by simple operation without using a specific optical element other than optical elements of an eyepiece optical system.
SOLUTION: The eyepiece optical system 3 has at least three optical faces 11, 13, 14 to form a prism body having at least one reflection surface 12 having positive power placed eccentrically or inclined to an observer's visual axis 2 and space formed by at least three faces 11, 13, 14 is filled with a medium which has refractive index larger than '1'. The prism body is constituted so as to be rotated or moved between a 1st arrangement position for guiding a light beam generated from a picture display element 4 to an observer's eyeball 1 and a 2nd arrangement position for passing a light beam from the outside and guiding the beam to the eyeball 1.



(a)



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* NOTICES *

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CLAIMS

[Claim(s)]
[Claim 1] In the image display device which consists of an image display component which displays an image, and eyepiece optical system which projects the image formed of said image display component, and is led to an observer's eyeball said eyepiece optical system A medium with a larger refractive index than 1 fills the space which has the 3rd [at least] page and is formed of the 3rd [at least] aforementioned page in an optical surface. Whether eccentricity is carried out to an observer visual axis Or the 1st arrangement location which leads the flux of light which consisted of a prism object with the reflector which has at least one forward leaning power, and emitted this prism object from said image display component to said observer's eyeball, The image display device characterized by rotation or being constituted movable between the 2nd arrangement location which is made to pass the flux of light from the external world, and is led to said observer's eyeball.
[Claim 2] The 2nd page which counters is an image display device according to claim 1 characterized by power serving as abbreviation zero to the flux of light from the external world which passes this 2nd page in said 2nd arrangement location in the field which constitutes said prism object.
[Claim 3]

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] About an image display device, especially this invention relates to small, the head which can observe an image, or a face wearing type image display device by the extensive field angle and high resolving, though it is lightweight.
[0002]
[Description of the Prior Art] The head of a helmet mold and a goggles mold or the face wearing type image display device is developed for the purpose of enjoying the image of a big screen the object for virtual realities, or individually in recent years. It is necessary to equip a head with this type of image display device, and to observe it. Therefore, in order not to apply a corporal burden to an observer as much as possible, it is important conditions that it is small and lightweight. The screen observed on the other hand, so that an observation field angle is large turns into a big screen, and feelings, such as presence and a feeling of devotion, can be strongly given to an observer. Therefore, it is the important conditions of an image display device that the field angle to show is an extensive field angle.
[0003] Moreover, a head or a face wearing type image display device be use as a terminal which be the output unit of a computer, and when operate the device around a keyboard, a mouse, etc., it be necessary to make an observer recognize the external world by actuation of control or a switch by the signal from the outside etc. at the times when emergency produce a head or a face wearing type image display device around in the midst use as a display of a game machine.
[0004] As a conventional image display device which observes an external world image through an image display device, there is a thing of Japanese Patent Application No. No. 101709 [three to]. This arranges an optical layer which makes the power of eyepiece optical system offset in the observer and the opposite side of eyepiece optical system, leads the flux of light from the external world to an observer's eyeball, and enables it to observe an external world image.
[0005]
[Problem(s) to be Solved by the Invention] However, in order that the thing of Japanese Patent Application No. No. 101709 [three to] may arrange another optical element in the outside of eyepiece optical system, when equipping a head, the amount of protrusions from the face becomes large, the balance of the whole equipment worsens, and weight also increases. Therefore, the corporal burden given to an observer was large.
[0006] this invention is ****** in view of such a conventional problem, and the purpose is offering the suitable image display device for the head wearing type image display device which can observe an external world image by easy actuation, without being able to observe an image display component by the extensive field angle and high resolving, and moreover using an optical element special in addition to the optical element of eyepiece optical system, though it is a small light weight.
[0007]
[Means for Solving the Problem] The image display device of this invention which attains the above-mentioned purpose In the image display device which consists of an image display component which displays an image, and eyepiece optical system which projects the image

formed of said image display component, and is led to an observer's eyeball said eyepiece optical system A medium with a larger refractive index than 1 fills the space which has the 3rd [at least] page and is formed of the 3rd [at least] aforementioned page in an optical surface. Whether eccentricity is carried out to an observer visual axis Or the 1st arrangement location which leads the flux of light which consisted of a prism object with the reflector which has at least one forward leaning power, and emitted this prism object from said image display component to said observer's eyeball, It is characterized by rotation or being constituted movable between the 2nd arrangement location which is made to pass the flux of light from the external world, and is led to said observer's eyeball.

[0008] In this case, as for the 2nd page which counters, in the 2nd arrangement location, it is desirable for power to serve as abbreviation zero to the flux of light from the external world which passes this 2nd page in the field which constitutes a prism object.

[0009] Moreover, in the 1st arrangement location, in case the flux of light emitted from the image display component carries out internal reflection with a prism object, it is desirable to be constituted so that total reflection conditions may be fulfilled.

[0010] The reason and operation which take the above configurations in this invention below are explained. In the image display device which consists of an image display component which displays an image, and eyepiece optical system which projects the image formed of that image display component, and is led to an observer's eyeball this eyepiece optical system A medium with a larger refractive index than 1 fills the space which has the 3rd [at least] page and is formed of the 3rd [at least] page in an optical surface. Whether eccentricity is carried out to an observer visual axis Or the 1st arrangement location which leads the flux of light which of a prism object with the reflector which has at least one forward leaning power, and emitted this prism object from the image display component to an observer's eyeball, It becomes possible to observe an electronic image and an external world image, without using a special optical element with rotation or constituting movable between the 2nd arrangement location which is made to pass the flux of light from the external world, and is led to an observer's eyeball.

[0011] Below, drawing 1 and drawing 2 are made reference and explained. Drawing 1 (a) is the side elevation of the image display device of this invention. Drawing 1 (b) is the perspective view which looked at the image display device of this invention from the observer side. Drawing 2 (a) is a side elevation at the time of rotating the image display device of this invention and moving. Drawing 2 (b) is the perspective view seen from the observer side at the time of rotating the image display device of this invention and moving. drawing 1 - drawing 2 -- setting -- 1 -- an observer's pupil location and 2 -- an observer visual axis and 3 -- for a protection-from-light means and 11, as for the 2nd page and 13, the 1st page of eyepiece optical system and 12 are [eyepiece optical system and 4 / an image display component and 5 / the 3rd page and 14] the 4th page.

[0012] the beam of light with which the beam-of-light path in the case of observing the image of the image display component 4 in the state of drawing 1 emitted the image display component 4 -- the 4th of the eyepiece optical system 3 -- page 14 -- passing -- the 3rd -- page 13 -- internal reflection of the 2nd page is carried out by 12, respectively, 11 [page / 1st] is passed and incidence is carried out to an observer eyeball by using the observer pupil 1 as an exit pupil. or [carrying out eccentricity of the eyepiece optical system 3 to the observer visual axis 2 in the image display device of this invention] -- or since it is a prism object with the reflector which has at least one forward leaning power, as an operation, it is similar with the concave mirror. Generally, compared with eyepiece optical system with a lens, generating of aberration of a concave mirror is small. Moreover, since a beam of light is folded up in the configuration which meets coincidence at the face, ** which realizes a small light weight is made. Therefore, there are few corporal burdens given to an observer and it is possible to offer a clear observation image.

[0013] it moves and rotates in the condition which shows this eyepiece optical system 3 in drawing 2 -- making -- the eyepiece optical system 3 -- 13 [page / 3rd] is made to approach an observer eyeball, and it counters further -- 12 [page / 2nd] is arranged to an observer eyeball and the opposite side, and it is made for each field to become an abbreviation

perpendicular to the observer visual axis 2 Incidence of the 2nd page of the beam-of-light path from the external world in this condition is carried out to 12, it passes 13 [page / 3rd] and incidence is carried out to an observer eyeball by using the observer pupil 1 as an exit pupil. It becomes possible to observe an external world image by this.
[0014] In addition, although the medium with a larger refractive index than 1 shall fill the space in which there are four optical surfaces and they are formed of those fields in the prism object which constitutes the eyepiece optical system 3, an optical surface can be constituted also as 3rd page and, of course, at least the 5th [or more] page can consist of the above configurations.
[0015] In addition, in the condition of observing the external world of drawing 2 , the thing which is the 2nd page which constitutes the eyepiece optical system 3, and which counters and which the 2nd page (refractive power) of the 3rd page of the synthetic power of 13 is abbreviation zero to 12 is desirable. According to such a configuration, since the flux of light from the external world turns into the abbreviation parallel flux of light and incidence is carried out to an observer's pupil 1, it can observe a clear external world image.
[0016] In the condition of drawing 1 , if the case where the flux of light emitted from the image display component 4 does not fulfill total reflection conditions in the internal reflection of the eyepiece optical system 3 is assumed, in order to observe an electronic image, it is necessary to give a mirror coat with 12 to 13 the 3rd page the 2nd page so that clearly from drawing 1 (a).
[0017] on the other hand, in observing an external world image, like drawing 2 , the eyepiece optical system 3 is rotated and it moves -- making -- the 2nd -- page 12 and the 3rd -- page 13 -- abbreviation -- although an observer is made to counter and it is made to arrange in the parallel condition, external world light must penetrate 13 [page / 2nd / page / 3rd] with 12. therefore -- the case where there is a demand which observes an electronic image and an external world image alternatively -- the 2nd -- page 12 -- 13 needs to carry out the 3rd page of a half mirror coat. however, this -- the image of the image display component 4, and an external world image -- any quantity of light -- about -- it will fall to one fourth. Moreover, since half mirror coats are usually multilayers, the costs of manufacture will be high and a manufacture process will also become long.
[0018] By the way, if the internal reflection side of the prism object which is the eyepiece optical system 3 fulfills total reflection conditions, since total reflection of all the beams of light emitted from the image display component 4 is carried out, they can observe a bright image. Since an electronic image and an external world image can be changed and observed, without carrying out a mirror coat or a half mirror coat, cost is reduced sharply and can also simplify a manufacture process.
[0019] Moreover, if movable, the so-called superimposition of the image display component 4 and the eyepiece optical system 3 which observes those images at coincidence will be attained at coincidence rotation or by making in agreement the exit pupil of an electronic image and an external world image.
[0020] Moreover, it is important to arrange the protection-from-light means 5, such as a liquid crystal shutter, in the outside of the observer of the eyepiece optical system 3 and the field of the opposite side in order to carry out a switch of an external world image and an electronic image. If the incidence of the light from the external world is not made not to be carried out to the eyepiece optical system 3 by the protection-from-light means 8, since there is a possibility that the light of the external world may carry out incidence to an eyeball always to observe an external world image, it becomes impossible to observe the high electronic image of contrast. On the contrary, it changes into the condition of drawing 2 , an image is not displayed on the image display component 4 and it can realize by making the protection-from-light means 8 into the transparent mode to observe only an external world image.
[0021] Moreover, as for 12, in the case of the reflector and drawing 1 which have at least one forward power which constitutes a prism object, and drawing 2 , it is effective on aberration amendment that it is [page / 2nd] the aspheric surface. This is important conditions in order to amend the comatic aberration generated in the reflector which carries out eccentricity, or is inclined and arranged from a visual axis especially high order comatic aberration, and a coma

flare.
[0022] or [carrying out eccentricity ahead / of an observer eyeball / like this invention] -- or in the image display device using the eyepiece optical system of the type which has the leaning reflector, since the beam of light which carries out incidence on a shaft in a reflector becomes slanting, complicated comatic aberration occurs in the medial axis of a reflecting mirror. This complicated comatic aberration becomes large as the angle of inclination of a reflector becomes large. since [however,] an image display component and an optical path will interfere if it is small and it is going to realize the image display device of an extensive field angle, and eccentricity or an angle of inclination is not enlarged to some extent -- extensive -- it becomes difficult to secure a field angle observation image. Therefore, the more it becomes a small image display device with an extensive field angle, the angle of inclination of a reflector becomes large and, the more how generating of high order comatic aberration is amended poses an important problem.
[0023] Since power of optical system can be made an unsymmetrical configuration to a visual axis and the effectiveness of the aspheric surface can be further used out of a shaft by making the 1st [at least] page into the aspheric surface for which eyepiece optical system is constituted and which carried out eccentricity of the reflector desirably in order to amend such complicated comatic aberration, it becomes possible to amend comatic aberration including a shaft top effectively.
[0024] As for the reflector which has at least one forward power which constitutes a prism object, it is effective on aberration amendment that it is an anamorphic side. That is, the Z-axis which makes forward the direction which tends an observer's visual axis toward eyepiece optical system from a zero so that a postscript may be carried out, The Y-axis which intersects perpendicularly with an observer's visual axis and makes a top forward from under the vertical direction, in view of an observer's eyeball, It is the field where the radius of curvatures within the X-Z side which intersects perpendicularly with an observer's visual axis, and intersects perpendicularly with the radius of curvature within a Y-Z side and this field when it is defined as the X-axis which makes the left forward from the right of a longitudinal direction, in view of an observer's eyeball differ.
[0025] This condition is conditions for amending the aberration from which a reflector arises to a visual axis eccentricity or since it leans. Generally, when the spherical surface is carrying out eccentricity, the curvatures to a beam of light differ in the field where plane of incidence and the beam of light which carries out incidence to the field cross at right angles in plane of incidence. For this reason, astigmatism also generates the observation image on the visual axis which a reflector hits in eccentricity or the eyepiece optical system inclined and arranged to a visual axis centering on an observation image before an observer eyeball like this invention for the reason for the above. In order to amend the astigmatism on this shaft, it becomes important that the radius of curvatures of the reflector which has at least one forward power which constitutes a prism object shall differ in the field which intersects perpendicularly with this in plane of incidence.
[0026] Moreover, if the reflector which has at least one forward power which constitutes a prism object is a free sculptured surface, since the effectiveness by the aspheric surface or the anamorphic side mentioned above can be satisfied, it is possible to amend effectively the aberration generated in eyepiece optical system.
[0027] Here, a free sculptured surface is a curved surface expressed by the following formula (1).

$$z=\sum_{n=0}^{k}\sum_{m=0}^{k'} C_{nm}\,x^{m}\,y^{n-m} \qquad \cdots (1)$$

Here, x, and y and z express rectangular coordinates and Cnm also makes multiplier [of arbitration], k, and k' arbitration.
[0028] In the above image display device, an observer becomes possible [observing the stable

image] by having a means to position an image display component and eyepiece optical system to an observer head.
[0029] Moreover, it has a means to position an image display component and eyepiece optical system to an observer head, and an observer becomes possible [observing an image in a free observation posture or the observation direction] by enabling it to equip an observer head.
[0030] Moreover, an observer becomes possible [observing comfortably with right-and-left both eyes] by having the support means which supports at least 2 sets of such image display devices at fixed spacing. Moreover, the image which gave parallax to the image display side of an image display device on either side is displayed, and it becomes possible by observing them with both eyes to enjoy a stereoscopic model.
[0031]
[Embodiment of the Invention] Below, the example 1 of the image display device of this invention is explained with reference to a drawing. Although the postscript of the configuration parameter of an example 1 is carried out, in the following explanation, the field number is shown from an observer's pupil location 1 as a field number of the other reverse trace to the eyepiece optical system 3. And the Y-axis and the observer visual axis 2 which makes an observer's iris location 1 a zero, intersect perpendicularly with the Z-axis and the observer visual axis 2 which makes forward the direction which tends the observer visual axis 2 toward the eyepiece optical system 3 from a zero, sees from an observer eyeball, and make a top forward from under the vertical direction as shown in drawing 3 (a), and how to take a coordinate cross at right angles, and defines it as the X-axis which makes the left forward from the right of a longitudinal direction, in view of an observer eyeball. That is, the inside of the space of drawing 3 (a) is made into a Y-Z side, and space and a vertical field are made into a X-Z side. Moreover, an optical axis shall be bent in the Y-Z side of space.
[0032] and about the field where eccentricity Y and Z and angle-of-inclination theta are indicated in the configuration parameter which carries out a postscript About the 2nd page, the location of the spacing given in the distance which meets the Z-axis from the 1st page becomes a reference point. The angle of inclination from the Z-axis of the eccentricity of Y shaft orientations of the plane peak of the field from the reference point and Z shaft orientations and the medial axis of the field is meant. The 3rd page and the 4th page Mean the angle of inclination from the Z-axis of the eccentricity of Y shaft orientations of the plane peak of the field from the plane peak of the 2nd page which is datum level, and Z shaft orientations, and the medial axis of the field, and it is related with the 5th page. The angle of inclination from the Z-axis of the eccentricity of Y shaft orientations of the plane peak of the field from the plane peak of the 4th page which is datum level, and Z shaft orientations, and the medial axis of the field is meant. The 6th page The angle of inclination from the Z-axis of the eccentricity of Y shaft orientations of the core of the field from the core of the 1st page which is datum level, and Z shaft orientations, and the medial axis of the field is meant. In that case, as for forward, theta means a counterclockwise rotation, and the spacing has shown the direction of a reverse trace as forward in accordance with the optical axis.
[0033] In each side moreover, an aspheric surface configuration symmetrical with nonrotation On the coordinate which specifies the field, they are Ry and Rx., respectively Paraxial radius of curvature within a Y-Z side (space), The paraxial radius of curvature in a X-Z side, Kx, and Ky, respectively X-Z side, the constant of the cone within a Y-Z side, and AR and BR -- respectively -- the Z-axis -- receiving -- the 4th aspheric surface multiplier [6th] symmetrical with rotation, and AP and BP -- respectively -- the Z-axis -- receiving -- rotation -- when it is the 4th unsymmetrical aspheric surface multiplier [6th], an aspheric surface type is as being shown below.
[0034] Z =[(X2/Rx)+ () [Y2/Ry]]/[1+{1 () - (1+Kx) X2/Rx 2-(1+Ky)}(Y2/Ry2)1/2]+AR[(1-AP) X2+(1+AP) Y2]2+BR[(1-BP) X2+(1+BP) Y2] 3 -- in addition The refractive index of the medium between fields is expressed with the refractive index of d line. The unit of die length is mm.
[0035] The optical-path Fig. of a Y-Z cross section in case drawing 3 (a) observes the image of an image display component about this example, Drawing 3 (b) is the optical-path Fig. of the Y-Z cross section in the case of observing the image of the external world. As for the 2nd page in

which one forms an observer's pupil location, the reflector where in an observer visual axis and 3 an image display component and 11 have the 1st page of the eyepiece optical system 3, and, as for 12, eyepiece optical system and 4 have [2] the forward power of the eyepiece optical system 3, and a transparency side, and 13, the 3rd page of the eyepiece optical system 3 and 14 are the 4th page of the eyepiece optical system 3 among drawing.
[0036] Horizontal angles of view of 30 degrees, the perpendicular field angle of 22.72 degrees, and the diameter of an exit pupil of the specification of this example are 4mm. the 2nd of the internal reflection side of the prism object which is the eyepiece optical system 3 in drawing 3 (a) -- page 12 -- 13 fulfills the 3rd page of total reflection conditions. Therefore, it becomes possible to observe both an electronic image and an external world image, without carrying out half mirror coating of these two fields that are reflectors.
[0037] When observing an electronic image, the actual beam-of-light path in this example As shown in drawing 3 (a), the bundle of rays emitted from the image display component 4 the eyepiece optical system 3 -- the 4th page is refracted by 14, incidence is carried out to the eyepiece optical system 3, total reflection of the 3rd page is carried out by 13, total reflection of the 2nd page is carried out by 12, the 1st page is refracted by 11, the eyepiece optical system 3 is injected, and it is projected into an observer's eyeball by using the iris location of an observer's pupil, or the winding core of an eyeball as an exit pupil 1.
[0038] In observing an external world image, as shown in drawing 3 (b), the prism object 3 is rotated in the direction of a clockwise rotation of drawing, and it is moving up. If based on the location of drawing 3 (a), it is made to move in 30.19-degree rotation and the direction of Y 20.16mm clockwise.
[0039] In actual use, as shown in drawing 1 and drawing 2 , the protection-from-light means 5, such as a liquid crystal shutter, are arranged on the outside of the eyepiece optical system 3. And the image of the image display component 4 is displayed and the image of the image display component 4 can be observed by shading with the protection-from-light means 5. Moreover, the image of the image display component 4 can be erased, the protection-from-light means 5 can be changed into a transparency condition, and an external world image can be observed by rotating the eyepiece optical system 3 and moving. Next, the configuration parameter of the above-mentioned example is shown.
[0040]
Field number Radius of curvature Spacing Refractive index Abbe number (eccentricity) (angle of inclination)
1 infinity (pupil) 28.736 2 Ry 85.714 1.6200 60.30 Rx 46.018 Y -10.163 theta -3.81 degrees Ky -20.000000 Z 0.000Kx -6.903310 AR 0.161497x10-5 BR -0.353389x10-9 AP -0.189573BP -0.293763 3 - 152.866 1.6200 60.30 Y 4.363theta 39.36 degrees Z 30.308 4 - 152.912 1.6200 60.30 Y 3.066 theta 38.35 degrees Z 10.883 5 Ry -53.262 Y 10.000 theta-17.11 degrees Rx 141.921 Z 60.600 Ky 0 Kx 0 AR -0.100878x10-5 BR 0.152172x10-9AP -0.149575x101 BP 0.942350 6 (image display component) Y -36.324 theta -21.14"Z 76.573 .
[0041] As mentioned above, although the image display device of this invention has been explained based on an example, this invention is not limited to these examples, but various deformation is possible for it. In order to constitute the image display device of this invention as a head wearing type image display device (HMD) 21, as a sectional view is shown in drawing 4 (a) and a perspective view is shown in this drawing (b), a head strap 20 is attached and it is used, equipping an observer's head. Drawing 4 (a) is a sectional view at the time of electronic image observation of drawing 1 .
[0042] The image display device of the above this invention can be constituted as follows, for example.
[1] In the image display device which consists of an image display component which displays an image, and eyepiece optical system which projects the image formed of said image display component, and is led to an observer's eyeball Said eyepiece optical system is fulfilled by the medium with a larger refractive index than 1 in the space which has the 3rd [at least] page and is formed of the 3rd [at least] aforementioned page in an optical surface. Whether eccentricity is carried out to an observer visual axis Or the 1st arrangement location which leads the flux of

light which consisted of a prism object with the reflector which has at least one forward leaning power, and emitted this prism object from said image display component to said observer's eyeball, The image display device characterized by rotation or being constituted movable between the 2nd arrangement location which is made to pass the flux of light from the external world, and is led to said observer's eyeball.
[0043] [2] The 2nd page which counters is the image display device of the above-mentioned [1] publication characterized by power serving as abbreviation zero to the flux of light from the external world which passes this 2nd page in said 2nd arrangement location in the field which constitutes said prism object.
[0044] [3] The image display device of the above-mentioned [1] publication characterized by being constituted so that total reflection conditions may be fulfilled in case the flux of light emitted from said image display component carries out internal reflection with said prism object in said 1st arrangement location.
[0045] [4] Said image display component and said eyepiece optical system are the image display device of the above-mentioned [1] publication characterized by rotation or the movable thing at coincidence.
[0046] [5] The image display device of the above-mentioned [1] publication characterized by arranging a protection-from-light means in the outside of said observer of said eyepiece optical system, and the field of the opposite side.
[0047] [6] The reflector which has at least one aforementioned forward power is the image display device of the above-mentioned [1] publication characterized by being the aspheric surface.
[0048] [7] The reflector which has at least one aforementioned forward power is the image display device of the above-mentioned [6] publication characterized by being an anamorphic side.
[0049] [8] The reflector which has at least one aforementioned forward power is the image display device of the above-mentioned [6] publication characterized by being a free sculptured surface.
[0050] [9] The image display device of the above [1] characterized by having a positioning means to position said image display component and said eyepiece optical system to said observer head to [8] given in any 1 term.
[0051] [10] The image display device of the above [1] characterized by having the support means which supports said image display component and said eyepiece optical system to said observer head, and being able to equip said observer head to [9] given in any 1 term.
[0052] [11] The image display device of the above [1] characterized by having the support means which supports at least 2 sets at intervals of [fixed] said image display device to [10] given in any 1 term.
[0053]
[Effect of the Invention] According to the image display device of this invention, it is a small light weight in a large observation field angle, and the suitable image display device for the head wearing type image display device which can observe an external world image by easy actuation can be offered, without moreover using an optical element special in addition to the optical element of eyepiece optical system so that clearly from the above explanation.

[Translation done.]